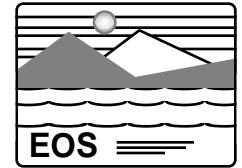




EOS AM-1 Mission Operations Review



EOS AM-1 SPACECRAFT OPERATIONS OVERVIEW

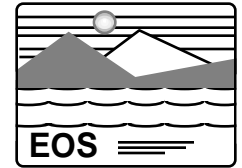
**PAUL WESTMEYER
EOS AM Project**

**Goddard Space Flight Center/Code 421
Greenbelt, MD 20771 USA**

E-mail: paul.a.westmeyer.1@gsfc.nasa.gov



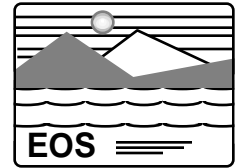
Unique EOS AM-1 Operations Topics



- **Tracking and Data Relay Satellite System (TDRSS) Onboard Navigation System (TONS)**
- **Science downlink transition from TDRSS (K-band) to X-band ground stations**
- **Direct Access System (DAS) scheduling**
- **Maneuvers**
- **Validation of Instrument Activation**



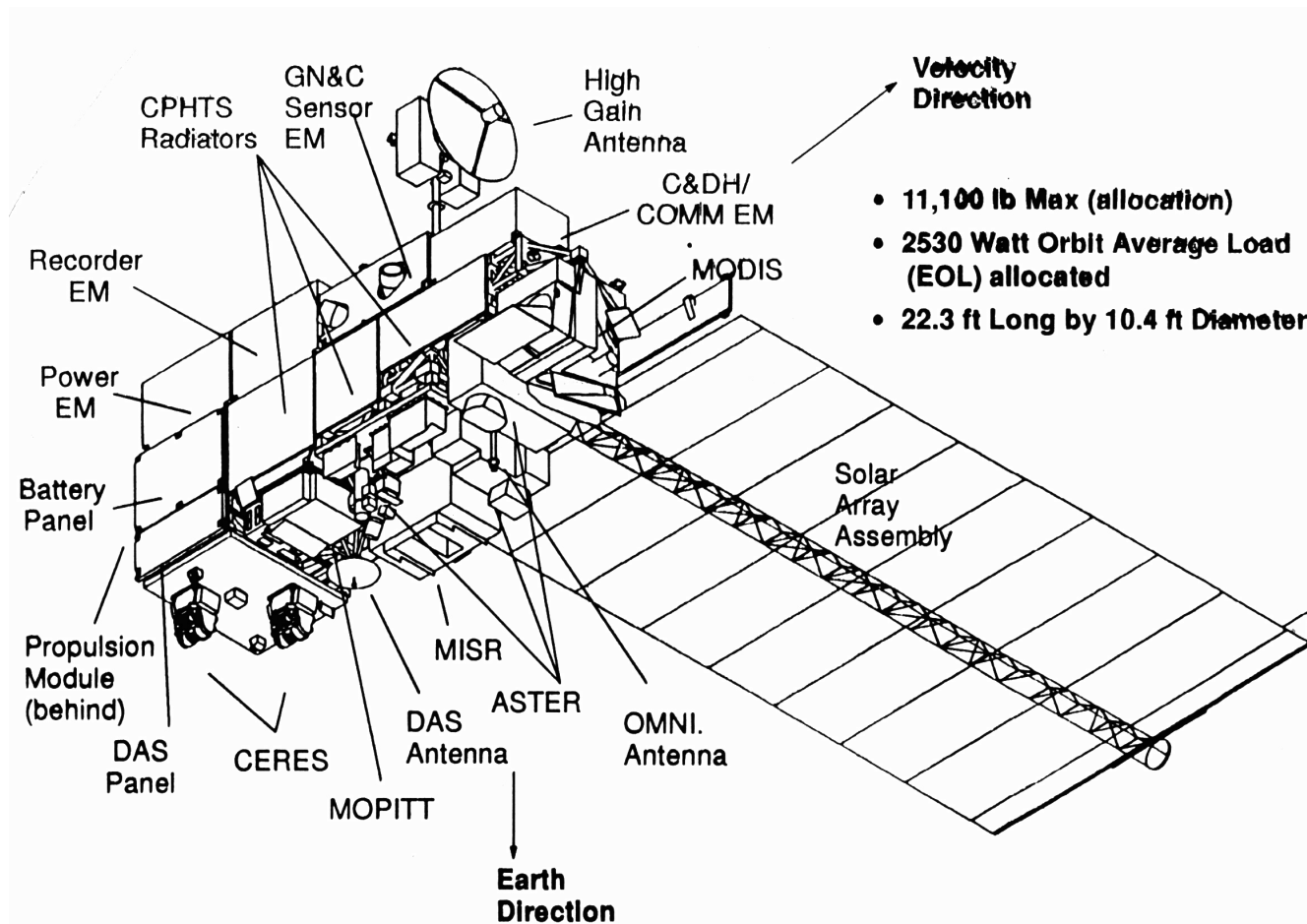
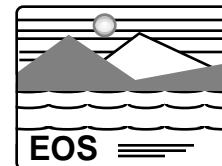
TDRSS Onboard Navigation System



- Determines satellite position
- Nominal performance → 15 meters (3 sigma)
- Baseline contact scenario – two 12-minute science contacts per AM-1 orbit plus one navigation contact
 - New TDRSS contact scenario being investigated by AM-1 Project – three shorter (8 to 9 minutes) science contacts
- Postprocessing possible, but not planned
- Post-2000 scenario still uses TONS – TONS contacts decoupled from science downlinks

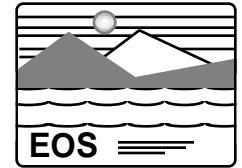


AM-1 Spacecraft Configuration





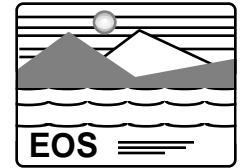
Science Downlink Transition from TDRSS (K-Band) to X-Band Ground Stations



- Two high-latitude northern sites selected: Norway and Alaska
- Backup capability at launch
- Full operations expected post-2000
- Different solid state recorder (SSR) management
 - TDRSS scenario had no *fixed* AM-1 orbit time for downlink of science data
 - Ground stations have known and fixed opportunities for science data downlink



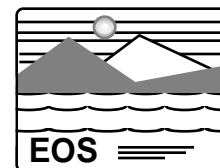
Direct Access System



- **Direct Broadcast mode – MODIS data**
 - Scheduled around Direct Playback
 - Radio Frequency (RF) Interference with Deep Space Network (DSN) being worked in western United States
- **Direct Downlink mode – ASTER data**
 - Scheduled (no schedule conflict with direct playback)



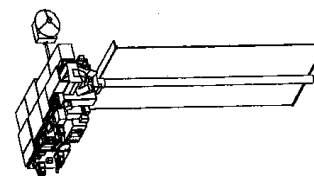
EOS AM-1 DSN/X-Band Interference Geometry



**Deep Space
Mission**

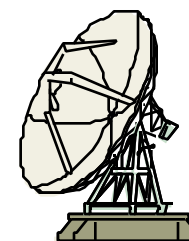


EOS AM-1



**Desired
Signal**

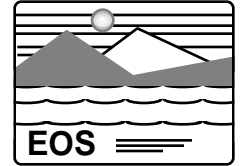
**Interfering
Signal**



DSN Site



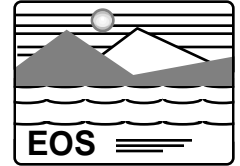
EOS AM-1 Maneuvers



- **Maneuvers used for**
 - Orbit initialization
 - Early orbit check-out of guidance, navigation, and control (GN&C) sensors
 - Orbit maintenance
 - Science instrument calibration
- **Three science maneuvers needed**
 - Small angle yaw
 - Small angle roll
 - Pitchover for deep space viewing and lunar viewing



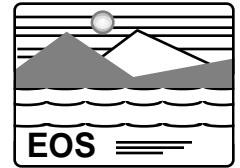
EOS AM-1 Maneuvers (Cont'd)



- **Pitchover is new science requirement deemed mission critical, within spacecraft functional capabilities**
- **Assumptions are:**
 - **Nominal spacecraft performance prior to event**
 - **Continuous TDRSS contact via single-access service**
 - **Wheel actuation only, no thrusters**
 - **Must return to nominal attitude before exiting Earth shadow**
 - **Others to be determined, definition in progress**



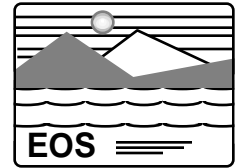
Instrument Activation/Validation



- **Instrument activation is part of the launch and early orbit activities**
- **Ordered sequence of events, building additional confidence with each new activity**
- **Instrument events will occur after the bus functions have been activated and validated**
 - **Some bus and instrument events may overlap**
- **Instrument validation will be performed at the Science Computing Facility (SCF)**



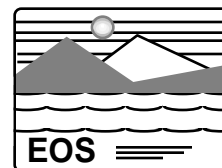
ASTER On-Orbit Initial Activations



- **ASTER Mission Checkout Timeline**
 - Reflects activity request from scientists
 - Includes latest plan of each subsystem
 - ASTER Initial Plan provided by ASTER IOT on November 7, 1996
- **Other instruments have less complicated validation sequences**



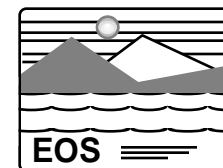
ASTER Mission Checkout Timeline



Day	Phase	EOS AM-1 Events Related to ASTER	ASTER System	VNIR	SWIR	TIR	CSP	MPS
L-1	Launch/ Acquisition	Solar array deployment	Transition from Launch mode to Survival mode (L+35 minutes) <i>Status Check</i>	Transition to Survival mode	Transition to Survival mode	Transition to Survival mode	Transition to Survival mode	Transition to Survival mode
2-8		6 Delta-V	Outgas and temperature monitor	Outgas	Outgas <i>Launch lock OFF (if possible) (under real-time contact)</i>	Outgas	Outgas	Outgas
9	Housekeeping Checkout	Mission orbit achieved CPHTS power ON	Launch lock OFF and MPS, CSP, and VNIR ON <i>(under real-time contact)</i>	VNIR Standby mode Launch lock OFF and verification	Launch lock OFF and verification	Cooler latch OFF and verification Scanner latch OFF and verification <i>Mirror to Cal position</i>	CSP Standby mode (side A)	Operational mode (side A)
10			Cooldown and ASTER Standby mode <i>(under real- time contact)</i> Function Check	Telescope temperature setting Telemetry Check	Cooldown transition to Standby mode (30 minutes)	Cooldown transition to Standby mode (30 minutes) <i>Telemetry Check</i> <i>Outgas</i>	Standby mode (side A) Telemetry Check Outgas	Operational mode (side A) Telemetry Check Outgas
11			Function Check	Pointing (A and B) (± 8.55 deg; ± 24 deg) <i>(under real-time contact)</i> Outgas	Pointing (Cal->Nadir- ± 8.55 deg-> ± 8.55 deg->Cal) <i>(under real-time contact)</i>	Operation Function Check	Standby mode (side A)	Operational mode (side A)



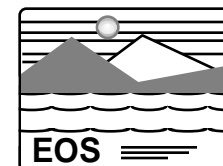
ASTER Mission Checkout Timeline (Cont'd)



Day	Phase	EOS AM-1 Events Related to ASTER	ASTER System	VNIR	SWIR	TIR	CSP	MPS
12	Housekeeping Checkout (cont'd)	SSR playback and transmittal via HGA and TDRS KSA service		Outgas	Observation and dark calibration <i>Mirror still at Cal position</i>	Short-term calibration		
13-39		ADAC and TONS long-term checkout (-39) Drag makeup burn (estimated) Ku-band pointing calibration (TBD)	Function and Performance Check Calibration sequence VNIR maximum observation (five continuous orbits * 4 days) SWIR maximum observation (five continuous orbits * 4 days) TIR maximum observations (five continuous orbits * 3 days) —	Performance Check <i>Calibration 1 (day 13)</i> <i>Observation 1 (days 16-17)</i> <i>Calibration 2 (day 29)</i> <i>Observation 2 (days 32-33)</i> —	<i>Performance Check</i> <i>Calibration (days 13, 21, 28, 37)</i> <i>Observation (4 days)</i> —	Function Check <i>Observation (days 13-15)</i> <i>Long-term calibration (day 16)</i> <i>Getter</i> <i>15 times short-term calibration (days 23-25)</i> <i>12 times long-term calibration (days 26-37)</i> —	Standby mode (side A) Telemetry Check VNIR check 2 out (A and B)	Operation mode (side A) Telemetry Check
40		Subsystem checkout complete						
41-90			TIR calibration sequence <i>ASTER calibration sequence (days 44-50, 52, 54, 56, 58, 62, 66, 74, 90)</i> S/T and V/S/T maximum observation (seven continuous orbits * 2 days) — Pointing angle calibration (4 days)	<i>Observation 3 (days 40-41)</i> <i>Calibration 3 (day 45)</i> <i>Observation 4 (days 48-49)</i> <i>Calibration 4 (day 54)</i> —	Pointing Observation Performance Check Standby mode	Performance Check <i>5 times long-term calibration (days 38-42)</i> <i>Observation (days 43, 51, 59, 67, 75, 83)</i> —	Standby mode (side A) Telemetry Check Performance Check Telemetry/comm unication HCE	Operational mode (side A) Telemetry Check Operational mode (side B) Telemetry Check Operational mode (side A)



ASTER Mission Checkout Timeline (Cont'd)



Day	Phase	EOS AM-1 Events Related to ASTER	ASTER System	VNIR	SWIR	TIR	CSP	MPS
41-90 cont'd	Housekeeping Checkout (cont'd)		Divided observation sequence (seven continuous orbits * 4 days) Observation transition sequence (seven continuous orbits * 4 days) Observations for Perform- ance Check (5 days) Side B test (2 days) <i>L+100</i> Reconfiguration (side A) (1 day)	VHC Standby mode (side A)		B Temperature Sensor Check Standby mode (side A)	TAXI Standby mode (side A)	

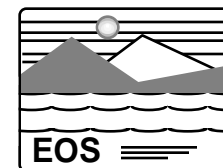
NOTE: From EOS AM-1/ASTER Twenty-Second Accommodation Meeting, October 21-25, 1996.

Limited Life Item Estimation During Initial Checkout		
VNIR	SWIR	TIR
Calibration lamp ON/OFF time: 18 Calibration lamp operation time: 3 hours Pointing time: 90	Calibration lamp ON/OFF time: 20 Calibration lamp operation time: 3 hours Pointing time: 130 Cooler ON/OFF time: 2 Cooler operation time: 1920 hours	Pointing time: 400 Cooler ON/OFF time: 3 Cooler operation time: 1920 hours Chopper ON/OFF time: 310 Chopper operation time: 10 hours

NOTE: From EOS AM-1/ASTER Twenty-Second Accommodation Meeting, October 21-25, 1996.



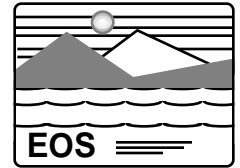
Flight Software



<u>Unit</u>	<u>Maintenance</u>	<u>Language</u>
Spacecraft Control Computer/Command and Telemetry Interface Unit (SCC/CTIU)	Lockheed-Martin, Code 512	Ada
MODIS	Hughes SBRS	Ada
MISR	JPL	Ada
CERES	LaRC	C
MOPITT	University of Toronto	C++



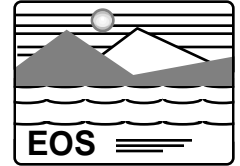
Flight Project Deliverables to FOT



- **Operations Concept**
- **Flight System Plan**
- **Flight Systems Manual**
- **Flight Systems Operations Manual**
- **On-Orbit Operations Manual**
- **Flight Software Users Guide**
- **Instrument Operations Interface Control Documents (OICDs)**
- **Command and Telemetry Definitions**
- **Spacecraft Trend Parameters/Limited Life Items List**
- **FOT training materials and training**



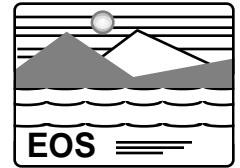
Link Margins



- All links meet requirements and have positive margin
- AM-1 X-Band antenna design has known null near 24 degrees (from nadir); this null may require some operational awareness
 - Specifications have 10-meter ground antenna; actual design has 11-meter
 - Specifications have commercial receiver gain; actual design expected to be several dB better
 - Expected to have 3-dB margin



Major Mission Events and Operations



- **Early orbit deployments**
 - **Solar array**
 - **High-gain antenna**
 - **Instrument protective covers**
- **Early orbit activation**
 - **GN&C maneuvers**
 - **Science maneuvers and calibration**
- **Power management – ASTER (duty cycle)**
- **Instrument activation/validation**
- **Science maneuvers – yaw, roll, and pitch**



EOS AM-1 Project Master Schedule

